

# Climate Change and Chance

## Will recovering fish stocks help puffins adapt to warming waters?

A recent paper <sup>(1)</sup> published by NOAA researchers found that 24 of 36 fish stocks on the Northeast Continental Shelf (an area that includes the Gulf of Maine) are shifting their ranges north and /or moving into deeper water. Seventeen are moving north at the surprising speed of 1-8 km per/yr, seventeen are moving to deeper and cooler water eight are moving north AND into deeper water. This trend is likely making some of the puffin's most important forage fish less available during the nesting season and contributing to the poor nesting success observed over the past two summers. One of the concerns for the future of puffins and other fish eating seabirds in the Gulf of Maine is that white hake and Atlantic herring are among the species affected by the warmer waters. These two species make up the bulk of the summer food consumed by puffins and terns. White hake are shifting their range northward and into deeper, cooler waters where puffins will have a more difficult time catching their meals. In most years, white hake makes up more than half of the meals delivered to Maine coast puffin and tern chicks. Likewise, Atlantic herring are also changing their occupied areas in response to warmer water.



**Atlantic Puffin with Herring**  
*by Derrick Z. Jackson*



**Atlantic Puffin with White Hake**  
*by Sandy Flint*

While fish can shift their range to find suitable water temperature, nesting seabirds have fixed limits as to how far they can travel from nesting islands because longer fishing trips require the parents to burn more energy to find ample food for themselves and their young. Can Maine puffins adapt to these changes in fish populations? Perhaps- but adaptation to climate change depends on chance factors such as which fish species move into the waters near the nesting islands and how many are available during the nesting season.

Puffin parents are quick to capture any small fish or marine crustacean to feed their chicks, but some foods are much better choices than others. If white hake and herring shift their ranges far from the nesting islands, it's likely that southern species will reoccupy the vacated habitat, but it is a matter of chance if the replacement species will be suitable for the seabirds. The importance of a prey item depends not only on calories, but the shape of the prey and number of obstacles such as spines that makes prey hard to swallow.



**Live Butterfish**  
by Stephen Kress



**Atlantic Puffin with Butterfish**  
by Nathan Banfield

We noticed, for example, that in 2012 parent puffins brought back larger than usual butterfish for their chicks, but the **chicks couldn't swallow them** because they were too wide-bodied for the chicks to consume. They tried, but to no avail. This anomaly, combined with insufficient white hake, herring and other foods, resulted in only 31% of puffin pairs fledged a chick at Seal Island National Wildlife Refuge, Maine's largest puffin colony. In contrast, usually about 77% of puffin pairs fledge a chick. Butterfish are becoming more abundant and larger, trends that will not help the puffins. In addition to warmer water, other factors are affecting the fertility of Maine's coastal water, such as decreasing salinity from melting arctic ice and increasing acidity from dirty air, loaded with acids and mercury that drifts over the Maine coast and precipitates into the water.

The dismal puffin reproduction of 2012 was likely a result of warmer than usual water that led to the earliest known plankton bloom for the Gulf of Maine. These conditions resulted in greatly reduced populations of zooplankton, notably the cold water, nutritious copepod *Calanus finmarchicus*. *This tiny zooplankton is the primary food that fattens puffin prey such as herring and hake.*

**The 2013 season** got off to a foreboding start when thousands of razorbills wandered far to the south of their normal range, some as far as the Florida Keys. Beach walkers soon started to find the razorbills coming ashore in starved condition. Later, others perished on their return to Maine, especially off the coast of Cape Cod where hundreds washed ashore in February and March. Some of the birds carried Project Puffin bands confirming that they were Maine natives. Although razorbills far outnumbered puffins among the losses, even a few starving puffins suggested big trouble at sea where many likely perished. Fertility of the Gulf of Maine was also lower than usual, perhaps because of a very weak, undetectable spring algae bloom. Typically, the spring bloom provides food for vast numbers of zooplankton that nourishes the small fish required by nearly all coastal birds.

At Matinicus Rock and Seal Island, where puffin nesting burrows are shallow enough to check for puffin eggs, Project Puffin staff discovered 1/3 fewer occupied nests in 2013 than in 2012. At these islands puffins laid eggs about two weeks later than normal and many abandoned their eggs. Only about 10% of these pairs succeeded in rearing a chick. Apparently, puffins were in poor condition following the stressful winter of 2012-2013. While there were few butterfish delivered to puffin chicks this past summer, it soon became apparent that puffin chicks were growing very slowly, providing evidence of insufficient food. Similar nesting failure also occurred at Machias Seal Island, the largest puffin colony in the Gulf of Maine. Here, only about 15% of the 6,500 puffin pairs produced fledgling in 2013. It's likely that many of the missing pairs took the year off because of poor condition at the

beginning of the nesting season and the general lack of suitable food. Because puffins may live for thirty or more years, taking an occasional nesting season off is a way of protecting the long-lived adults.

**A surprising twist** to the disappointing 2013 nesting season occurred at the restored puffin colony on Eastern Egg Rock, the southernmost Maine puffin colony (near Boothbay and New Harbor). In contrast to the poor nesting season at other Maine puffin colonies, this colony increased from 104 pairs in 2012 to 111 pairs in 2013 and most pairs fledged chicks. Unlike the Matinicus Rock and Seal Island colonies, puffins at Egg Rock found ample white hake and herring and supplemented their diet with redfish, a commercially important fish known as 'ocean perch.' Haddock, another commercially important food is also showing up in puffin diets in increasing numbers. Both redfish and haddock were over fished in previous decades, but are now increasing due to effective fishery management regulations. And fortunately, neither is shifting their ranges northward or into deeper water. This chance event of the timely recovery of haddock and redfish stocks may help puffins if hake and herring populations become less available.

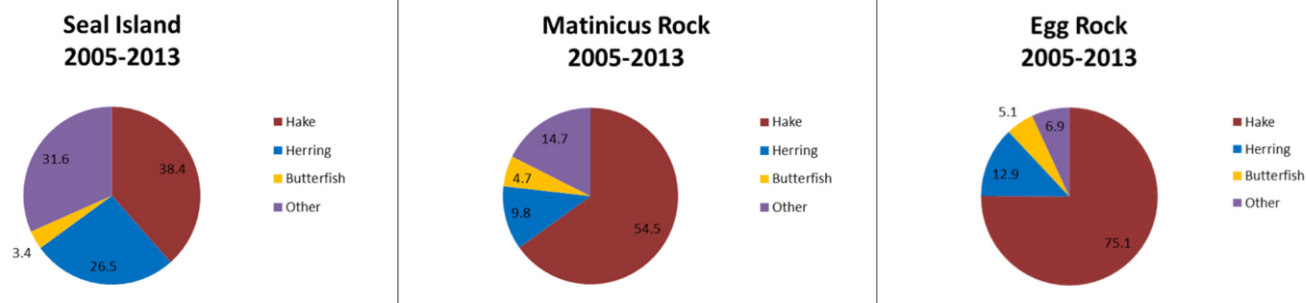
**Maintaining multiple nesting islands is an important strategy** for conserving colonial birds such as puffins. Multiple colonies reduce the risk of predators wiping out all of the species in a region. But the approach of managing multiple colonies can also help birds adapt to climate change as each puffin nesting island has its own distinct 'signature' of forage fish. Seal Island and Matinicus Rock are just nine miles apart and parent puffins bring back similar types of food, suggesting that they feed together. In contrast, Egg Rock puffins, located 35 miles southwest of Matinicus Rock, probably frequent a different fishing hole. Comparison of the foods fed at Matinicus Rock and Egg Rock show that Egg Rock puffins are finding ample food from the same kinds of fish over the past nine years, but Matinicus Rock puffins are feeding on more varied food and still not able to bring home enough calories. Future projects tracking puffins with miniature GPS tags will help to clarify key information about where puffins find food and better help managers to protect these vital feeding places.

**Recovering fisheries may help puffins adapt to changing climate.** The pressing question is: Was 2012-2013 an anomaly or the new normal? Ongoing observation at puffin nesting islands will help to answer this question. It's also clear that protecting fish resources from over fishing is becoming increasingly important, giving seabirds a chance to adapt to changing conditions.

If white hake moves out of reach of the nesting islands, what species will replace it? Perhaps a well-managed herring population can make up for less hake and take up the slack. Also, new fish from warmer waters will also enter the puffin's domain. These unknowns point to the huge role of chance events associated with climate change.

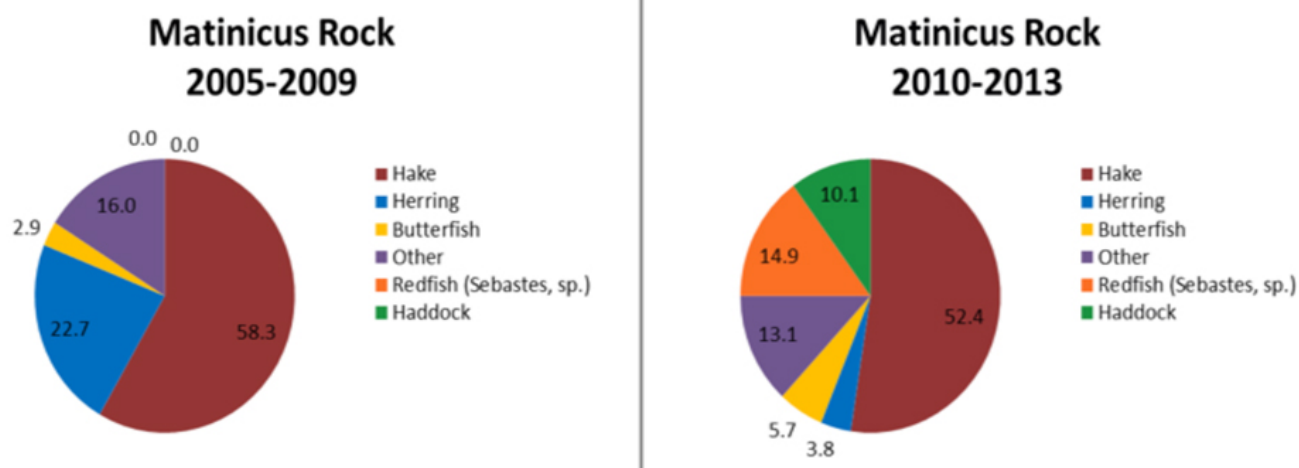
For example, this summer, a wide-bodied southern fish, the Atlantic moonfish *Selene setapinnis*, showed up in most Maine tern colonies for the first time. Even more difficult to swallow than a butterfish, the moonfish were found scattered through the tern colonies, rejected by the tern chicks that could not swallow them. Yet there are also promising alternate foods for puffins that are an ideal size for adults and chicks to swallow. Juvenile bluefish, Atlantic mackerel, Atlantic saury, sand lance, redfish and haddock are suitable forage fish and they are showing up in puffin diet in increasing numbers. Because most of these fish are also commercially important, it is vital for fisheries to start thinking of seabirds and other marine life when setting fishing policies. The recent recovery of redfish and haddock is in part a response to the Magnuson-Stevens Fishery Conservation and Management Act. That puffins are finding these recovering fish stocks in years when hake and herring were in short supply is a promising example of how well-regulated fisheries can lead to recovering fish stocks that in turn can benefit seabirds. Such success may help to give puffins and other fish-eating wildlife time to adapt to changing conditions in the Gulf of Maine.

While there are many unknowns and chance events related to puffin forage fish, the ongoing management of Maine puffin islands- chasing off predators such as gulls, eagles and ravens will help to reduce losses to predators that would otherwise take adult and nestling puffins. Keeping the adult populations strong is an important part of the future strategy for puffin management, so that they can continue to thrive when conditions favor successful nesting seasons.



The three puffin colonies in mid-coast Maine have distinct patterns of fish which they feed their young. While there is considerable variation between years even on the same island, the long term average shows that each island has a distinct signature of forage fish that puffin use to feed their young. On all three islands, white hake is the principal food, but it is especially important at Eastern Egg Rock where it makes up about 75% of the food fed to puffin chicks. Seal Island and Matinicus Rock have a more diverse diet, which now includes redfish (*Sebastes* spp.) and haddock as significant elements. When compared, Seal Island and Matinicus Rock have statistically the same diet; while Egg Rock is different. This suggests that the Egg Rock puffins are feeding in a different location than the puffins at Matinicus Rock and Seal Island.

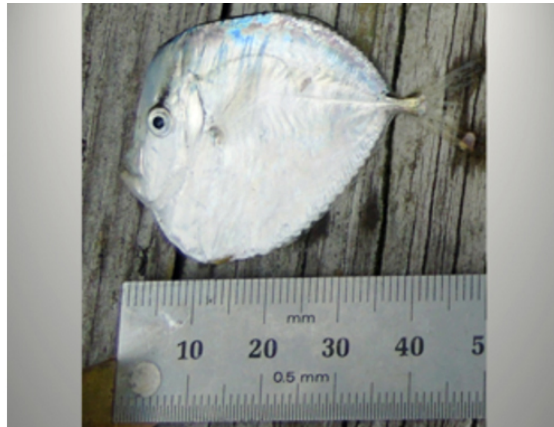
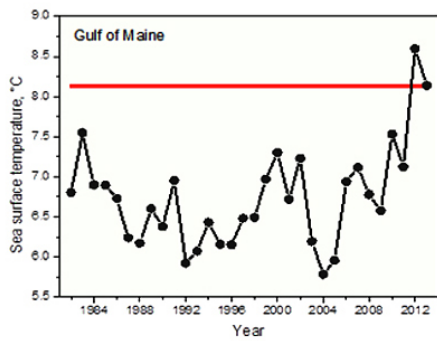
Over the nine year study period 2005-2013, fish fed to puffin chicks at Eastern Egg Rock have remained similar in species and proportion, with white hake making up about three fourths of the chick diet.



*Forage fish fed to puffin chicks at Matinicus Rock 2005-2013*

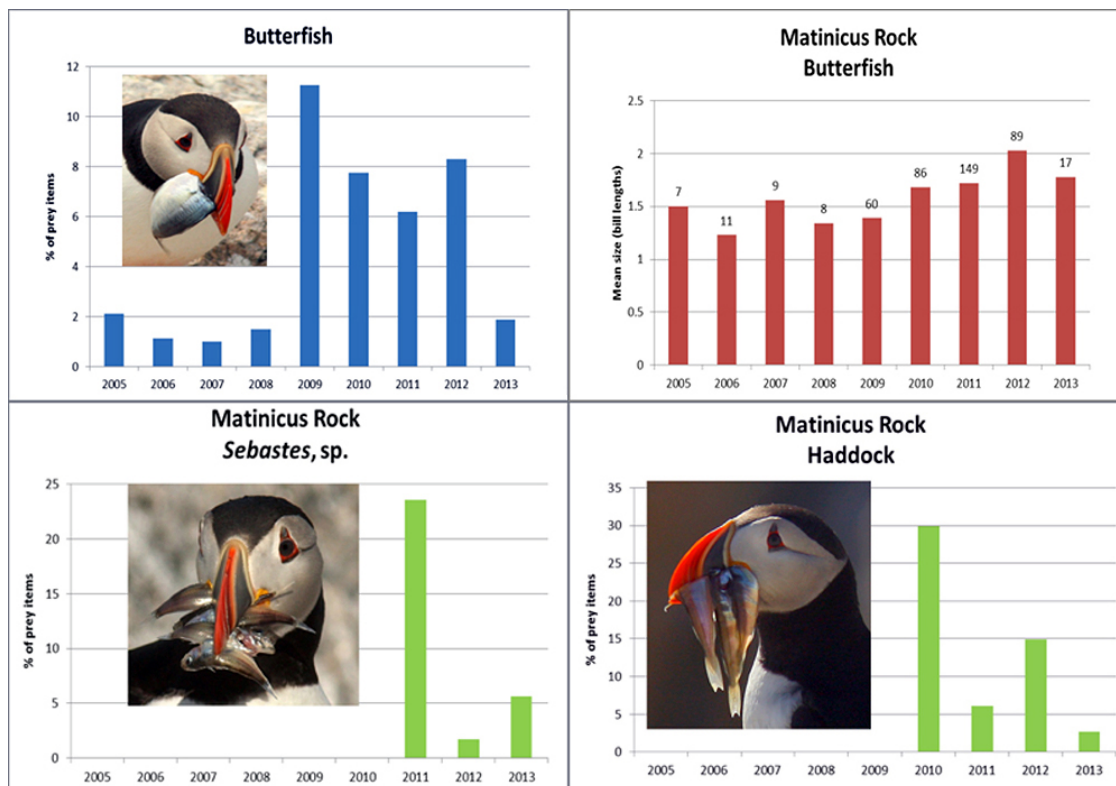
Beginning in 2010, Matinicus Rock puffins began supplementing their chick diet with substantial amounts of butterfish, haddock and redfish.





Temperature Graph courtesy of NMFS/NOAA; Atlantic Moonfish photo by Emily Pollom  
*Gulf of Maine Sea Surface Temperatures at left; red line indicates 2013*

During the first six months of 2012, oceanographers documented the warmest sea surface temperatures known for the Gulf of Maine. The first six months of 2013 were only slightly cooler and notable for an undetectable phytoplankton bloom. Warmer water results in low amounts of phytoplankton and relatively little zooplankton, the basic food for small fish that nourish puffins and other seabirds. Warm water also permits new fish to move into the Gulf of Maine. These may prove suitable meals for seabirds, but others such as the Atlantic moonfish (above) has too broad of a body shape for puffin and tern chicks to swallow. Graph courtesy of NMFS/ NOAA.



Changes in fish fed to puffin chicks at Matinicus Rock and Seal Island. Since 2010, the number and size of butterfish has increased as has the number of redfish (*Sebastes spp.*) and haddock in the diet of Maine puffin chicks.

(1) Nye, Janet A, Jason S. Link, Jonathan A. Hare and William J. Overholtz. 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. *Mar Ecol Prog Ser.* 393:111-129